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Use of Shrub Habitats by Fall Birds at Iroquois National Wildlife Refuge, Alabama, New York

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By

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Abstract

Many studies have suggested that early successional habitats are important for fall migrants and resident birds. In light of this, I studied birds at Iroquois National Wildlife Refuge, Alabama NY, to determine habitat relationships, fruit consumption, and utility of transects and mist nets for counting birds in early successional habitats during the fall. I used transects to count birds in 18 sites (12 shrub and six forest) during the fall in 2008 and 2009, and collected habitat data to construct habitat models. I examined frugivory of fall birds by employing a paired open/enclosed fruit branch method and by analyzing fecal samples. I also sampled birds using mist nets and transects simultaneously to determine if the two methods yield similar estimates of bird abundance.

More birds were detected in shrublands than in forests across the two years. Total bird abundance was affected positively by fruiting species richness and negatively by small stem abundance. American Robin (*Turdus migratorius*) abundance was positively related to total shrub cover and common buckthorn (*Rhamnus cathartica*) fruit abundance, and negatively related to both small and large stem abundance. Gray Catbird (*Dumetella carolinensis*) abundance was positively related to fruiting shrub species richness. Song Sparrow (*Melospiza melodia*) abundance was positively related to gray dogwood (*Cornus racemosa*) fruit abundance, and negatively related to small stem abundance and bella honeysuckle (*Lonicera X bella*) fruit abundance. Birds as a whole consumed fruit disproportionately relative to availability, consuming more bella honeysuckle and common buckthorn than gray dogwood. Fruits disappeared from open shrub

branches significantly faster than netted branches, suggesting frugivory occurred. Mist nets detected a greater species richness than transects in all fields and years. Correlations between mist net and transect bird abundances were mixed, with significant positive relationships for larger, noisy species such as Gray Catbirds, American Robins, and Song Sparrows, but not for small, cryptic species. My results suggest shrublands that contain fall fruiting shrub species are the best habitats to manage for fall birds. Also, transects are an adequate method of sampling fall birds in early successional habitats given several important qualifiers related to detectability.

General Introduction

Early successional habitats, including grasslands, shrublands, and early successional forests, have been declining in the Northeast as many of these areas revert to forest (Litvaitis 1993, Foster *et al.* 2002). While forest-dwelling wildlife species are gaining habitat, early successional species are losing quality habitat at a high rate (Litvaitis 1993). Some research has suggested that many migrants and fall resident birds use early successional shrublands as stopover sites and gain mass by consuming fruits, which are plentiful during fall migration (Parrish 1997, Bonter *et al.* 2007, Smith *et al.* 2007). Some of these Neotropical and Nearctic songbirds have experienced large declines over the past few decades (Morris *et al.* 1996, Donovan *et al.* 2002, Smith *et al.* 2007). Thus, understanding habitat relationships during the fall is crucial to conserve and manage the landscape for these species.

Chapter 1 of my thesis describes the main results of my study: determining the habitat characteristics fall songbirds select for in early successional sites, including vegetation type and structure, and fruit availability. I used 18 fields, including12 shrubland and six forest patches, within Iroquois National Wildlife Refuge in Alabama, NY, during the fall of 2008 and 2009. I sampled bird abundance with transects, measured habitat variables, and produced four habitat models, including three for individual species and one for total migrant abundance, in order to predict habitat use and guide habitat management decisions. The second objective of my habitat study was to determine which fruits fall birds consumed in early successional habitats, which I analyzed with experimental and observational methods. The

experimental method entailed covering one branch from five individuals of each fruiting species with a fine mesh net to prevent birds from eating the fruit. Fruits from both branches were counted each week to see if unnetted branches lost fruit faster than netted branches, indicating loss due to frugivory. The observational method entailed analyzing fecal samples from netted birds to show the level of frugivory within and among species.

While I used transects to determine bird abundance for Chapter 1, I needed to determine the utility of both transects and mist nets for counting fall birds in early successional habitat. Each method has advantages and disadvantages. Bird detectability is one potential problem with transects, but transects have the advantage of being quick and easy to perform. Mist nets require more resources and training to perform but have fewer issues with detectability. Chapter 2 contains my comparisons for mist net and transect bird counts of total bird, American Robin, Song Sparrow, Gray Catbird, warbler, and common species combined abundance. Chapter 2 also contains a comparison of the species richness as determined by these two methods.

A Comparison of Shrubland and Early Successional Forest Use of Fall Birds in Western New York

Introduction

Shrublands and early successional forests have declined in the Northeast as they have matured into secondary forests (Foster *et al.* 2002). This decline has lowered the available habitat for early successional habitat specialists (Litvaitis 1993). Recent research has suggested that many songbirds, both residents and migrants, use these habitats extensively during the fall (Rodewald and Brittingham 2004, Packett and Dunning 2009). Although previous studies have provided invaluable information on migrants, there are still many gaps in our understanding of their ecology and physiology, including what constitutes suitable stopover habitat for migrant songbirds.

Migratory songbirds spend up to three months of the year at stopover sites; therefore, having stopover habitat available in sufficient quantity and quality is important (Mehlman *et al.* 2005). These stopover sites are necessary for both resting and refueling (Parrish 2000, Bonter *et al.* 2007), as many small birds are unable to store enough fat to allow them to fly nonstop from their breeding to wintering grounds. An increasing number of studies point to fruits, particularly those found in early successional shrublands, as an important source of energy for migrants during the fall (Parrish 1997, Smith and McWilliams 2010). While a diet containing both fruits and insects yields the best mass gains during stopover (Parrish 1997), insect abundance alone does not seem to be a good predictor of fall migrant habitat use in early successional canopy gaps (Champlin *et al.* 2009).

The main objective of this study was to determine which vegetation and landscape characteristics migrant and resident songbirds select for during the fall at Iroquois National Wildlife Refuge (INWR), and model habitat use for the most common species. I used all birds encountered in the study, including species that used the site for migration stopover, as well as local breeders that used the habitat as a staging ground for migration. I limited site selection to shrublands and early successional forests as previous literature suggested these areas are important stopover habitats during the migration (Packett and Dunning 2009). My secondary objectives were to determine fall frugivory levels among species, and preferred fruits. Results of this study elucidate habitat relationships for fall migrants and residents in early successional habitats, and provide suggestions for managing these habitats.

Methods

Site Description

All sites were located at (INWR) in Alabama, New York (43°6'44.6", 78°24'12.9"). INWR is approximately 4400 ha and contains a variety of habitats including grasslands, shrublands, hardwood swamps, meadows, and freshwater marshes (USFWS 2010). I sampled 18 sites, including 12 shrublands and six early successional forest patches, from 1 September through 15 October in 2008 and 2009. I did not select sites randomly due to limited availability of early successional habitats at INWR and the need to sample specific habitat types. Shrublands were selected to include a wide range of habitat characteristics, from young and sparse to old and dense, and contained the natives gray dogwood (*Cornus racemosa*) and red osier dogwood (*Cornus sericea*), and the non-natives bella honeysuckle (*Lonicera* X

bella), common buckthorn (*Rhamnus cathartica*), and Russian olive (*Elaeagnus angustifolia*). Forests were primarily younger, second growth stands and contained mostly green ash (*Fraxinus pennsylvanica*) and American elm (*Ulmus americana*), with lesser amounts of black walnut (*Juglans nigra*) and oaks (*Quercus* spp.). Each forest patch was adjacent to a paired shrubland site, while most shrubland sites used were separated by >250m. The landscape was a mosaic of habitats with forest surrounding many sites, though swamps or grasslands abutted some of the sites.

Habitat Characterization

I used methods similar to those in James and Shugart (1970), with a few modifications, to characterize vegetation (Rodewald and Brittingham 2004). Four 5.0 m radius plots were established in a randomly stratified design 12.0 m off bird counting transects. Within each plot, I estimated both total and individual species shrub cover and counted shrub stems in the following categories: 0-2.5 cm and 2.5-8.0 cm diameter (measured 10 cm above ground).

Within each 5.0 m radius habitat plot I calculated an index of fruit availability for each shrub species by multiplying the shrub cover by the estimated percent of the branches bearing fruit [Fruit Index = (Shrub Cover) * (Percent Branches with Fruit)]. The total fruit availability index was calculated by summing all individual species indices [Total Fruit Index = Σ (Individual Species Indices)]. I also counted the number of shrub species bearing fruit per plot as another indicator of fruit availability.

Bird Surveys

I used transect counts instead of mist nets to quantify bird abundance because transects require fewer resources and previous studies have shown that transects and

mist nets yield generally similar estimates of overall migrant abundance in early successional habitats (Smith and Hatch 2008, Chapter 2). Transects were located in the center of each site and varied in length according to the size of the field. Dense fields had lanes 1-2 m wide cut by a brush hog or hand loppers to minimize disturbance to birds while walking transects. Each site was visited seven to eight times each year, with the exception of three sites that were visited up to 15 times each year to compare mist net and transect data (Chapter 2). Single observer transects were walked at ~1.0 km/hr between 0600 and 1000. Observers counted all birds using the habitat (excluding flyovers) and recorded them to species and sex if possible. Unidentified birds were grouped into generic categories such as "Bird", "Sparrow", or "Warbler".

Fruit Consumption

I used two methods to determine if fall birds consumed fruit in early successional habitats at INWR in 2009. First, I collected fecal samples from some birds caught in mist nets to look for signs of fruit consumption. I removed birds from the mist net and placed them in a paper bag for ~30 min. to collect fecal samples. Indicators of fruit consumption included seeds or pulp in the feces as well as coloration (red, purple, etc.). I noted presence/absence of fruit for each fecal sample, rather than volume or mass, since I wanted to determine what fruit species the birds consumed rather than determine total intake. While I could not determine if fruits in fecal samples were consumed at my study sites, rapid gut passage times for fruits consumed by birds make it likely that they were consumed at least nearby (Gill 2007). Second, I used an experimental field approach to determine if birds consumed

fruits from shrubs (Smith *et al.* 2007). I counted fruits from two branches per individual shrub, one control and one enclosed with a fine clear mesh, once per week throughout the fall to determine if consumption occurred. I used five individual shrubs per common species, gray dogwood and bella honeysuckle, in two shrublands and one forest site in 2009. Pairing branches in this manner allowed me to determine the amount of fruit lost from the shrub beyond that due to senescence. Additionally, I counted fruits during paired late evening/early morning counts to determine if small nocturnal mammals consumed fruits.

Statistical Analysis

I only included data from shrub sites to make habitat models since I saw few birds in forest sites. Prior to modeling, I standardized predictor variables (Z-score) to remove unit effects and then examined them in a correlation matrix to remove highly correlated variables ($r>0.70$) (Shaw 2003). Non-normally distributed data were transformed with either arcsine square root (proportion data) or $\log_{10}$ (count data) transformations to improve normality (Zar 1999) (Appendix 1). I used backwards model selection with the Generalized Linear Model (GLM) module in SPSS 17.0 to generate habitat models based on total bird abundance and for species with large enough sample sizes (>30 detections in each year), Gray Catbird (*Dumetella carolinensis*), American Robin (*Turdus migratorius*), and Song Sparrow (*Melospiza melodia*). I selected best habitat models using the second order Akaike's Information Criterion (AICc) and reported full models with a Δ AICc <2.0 (Anderson and Burnham 2002). Finally, I used Akaike weights to determine the likelihood of each model being the best model given the current dataset (Anderson and Burnham 2002).

To compare relative abundance of birds between forest and shrub habitats, I analyzed transect data using the Wilcoxon ranked sum test for the six paired, adjacent shrublands/forests and the Mann-Whitney test for all twelve shrublands and six forests (Zar 1999). I used the half-cosine model in Distance 6.0 to calculate detection probabilities for all birds observed in shrubland and forest patches to help understand the relative use of these habitats (Thomas *et al.* 2010). While grouping species together like this may not be the best method due to differences in bird morphology and behavior, small samples sizes required me to group species to calculate the detection probability for forest birds. I did not correct individual species abundances for detection probability in the habitat modeling procedure since I modeled species separately, did not combine the two habitat types, and had low sample sizes.

I analyzed data from the fruit removal experiment with a Wilcoxon ranked sum test in SPSS 17.0 to test the hypothesis that open branches lost fruit at a significantly faster rate than netted branches for both species combined. All five individuals per species per field were averaged together for each date, resulting in seven date pairs for each of the three analyses. I also analyzed bella honeysuckle and gray dogwood separately to test the same hypothesis. I analyzed fecal data with a non-parametric χ^2 goodness-of-fit test to see if migrants consumed various fruit species disproportionately relative to the fruit availability estimates.

Results

Habitat Use

I walked 291 transects throughout the study, including 133 in 2008 and 158 in 2009. Gray Catbirds, American Robins, and Song Sparrows were the most common

species observed in this study, making up 43.6 % and 50.2% of all birds counted in the transects in 2008 and 2009, respectively. Other common species included White-throated Sparrow (*Zonotrichia albicollis*), Common Yellowthroat (*Geothlypis trichas*), American Goldfinch (*Spinus tristis*), and the Black-capped Chickadee (*Poecile atricapillus*). I was unable to identify 15.1% of the birds to species and therefore classified 3.3%, 11.5%, and 0.2% of the detections as "Bird", "Sparrow", and "Warbler" respectively. Bird detections did not differ significantly between years for shrub sites (Wilcoxon: Z= -1.490, p= 0.136), although differences appeared significant for forest sites (Wilcoxon: Z= -1.826, p= 0.068), and for shrub and forest sites combined (Wilcoxon: Z= -1.862, p= 0.063). There was no significant difference in bird detections between shrub and forest sites in 2008 when looking across all 18 sites (Mann-Whitney: U= 22.0, p= 0.213); however, more birds were detected in shrub than forest sites in 2009 (Mann-Whitney: U= 13.0, p= 0.032) and when years were combined (Mann-Whitney: U= 74.0, p= 0.019) (Figure 1). When looking at the paired sites alone, there was no significant difference in bird detections between forest and shrub sites in 2008 (Wilcoxon: Z= -0.524, p= 0.600), 2009 (Wilcoxon: Z= -0.734, p= 0.436), and years combined (Wilcoxon: Z= -0.941, p= 0.347). Detection probabilities for all birds in shrubland and forest patches were 0.18 (95% CI=0.17-0.20) and 1.00 (95% CI=0.67-1.00), respectively.

The habitat model gaining the greatest support for total bird abundance suggested that more birds were detected in areas with more fruit-bearing shrub species and fewer small shrubs; the second-best model included a negative relationship with field area (Table 1). Both of these models included year as a

significant factor. The best American Robin habitat model suggested that detections increased with increasing total shrub cover, decreasing numbers of stem classes 1 and 2, and increasing buckthorn fruit abundance (Table 2). The best Gray Catbird habitat model suggested that detections increased with greater fruiting species richness (Table 3). Song Sparrows had three closely ranked habitat models. These models suggested that detections increased with gray dogwood fruit abundance and decreased with stem class 1 abundance and honeysuckle fruit abundance (Table 4). Year was also included in the model with the lowest AICc value.

Fruit Consumption

Of the 93 fecal samples collected, 27.7% contained at least one fruit species, with 11.1% of the samples containing material from honeysuckle, 3.3% from dogwood, 15.5% from buckthorn, and 2.2% contained more than one species (Figure 2). Six of the eight bird species sampled contained evidence of fruit in feces, with Gray Catbird (88.8%), Cedar Waxwing (55.5%), American Robin (50.0%), White-throated Sparrow (19.0%), Black-capped Chickadee (16.6%), and Song Sparrow (5.5%) showing the most to least evidence of frugivory. The American Goldfinch and Common Yellowthroat showed no evidence of frugivory. Birds consumed fruits at different rates relative to abundance (χ^2=12.920, df=2, p=0.002), with honeysuckle and buckthorn being consumed at rates greater than expected and dogwood less than expected (Table 5).

For bella honeysuckle and gray dogwood combined, open branches had a significantly lower proportion of fruits remaining than netted branches throughout the course of the fall (Wilcoxon: Z= -2.201, p=0.028) (Figure 3). Bella honeysuckle

showed the same significant trend (Wilcoxon: Z= -1.992, p=0.046) while gray dogwood showed no difference in the proportion of fruit remaining on the two branch treatments (Wilcoxon: Z= -0.105, p=0.917). There was no difference in the proportion of fruit remaining between the late evening and early morning counts (t=1.034, df=29, p=0.310), suggesting that small mammals did not play a role in fruit removal. In addition, there were no indications of deer browse on fruiting branches.

Discussion

Habitat

My data suggested that fall songbirds at INWR prefer shrubland habitats to forest habitats as stopover sites or as staging grounds for migration, a trend also reported by Rodewald and Brittingham (2004) in Pennsylvania and Packett and Dunning (2009) in Indiana. These numbers were not corrected with detection probabilities, which suggested that a lower proportion of birds were detected in shrublands than forest patches. These detection probabilities may not be ideal due to the small forest sample size (n=68) and grouping of species, however, I believe the difference in detection probabilities to be true in a relative sense based on the non-overlapping 95% confidence intervals and field observations. Assuming this difference in detection probability for shrubland and forest birds is true, it magnifies the finding that fall birds prefer shrublands to forests at INWR and agrees with other literature from the Northeast indicating the importance of shrubland habitats for fall birds (Suthers *et al.*2000, Rodewald and Brittingham 2004, Packett and Dunning 2009).

Although transect detections were nearly two times greater in shrubland patches than forest patches, one forest patch did not follow this trend and each year yielded almost as many bird detections as some of the best shrublands. This forest patch had a more open canopy and well-developed understory, which consisted of large, fruit-bearing honeysuckle shrubs. Bird use of this forest patch suggested that birds at INWR may use forests extensively during the fall as long as the shrub layer is well developed.

The best habitat model for total bird abundance suggested that migrants and fall residents prefer mid-successional shrublands with a wide variety of fruiting shrub species. The negative relationship between total bird abundance (primarily shrub/sapling breeding species) with small stem (0-2.5 cm) abundance is a reversal of what Rodewald and Brittingham (2004) found; however, the discrepancy may be due to the differences in study sites used. My habitat models were based on younger successional sites, including young shrublands dominated by small stemmed plants. Rodewald and Brittingham (2004) used sites from shrub/sapling forest up to mature forest interior sites that probably had low densities of small stems. The negative relationship with small stems in my study and positive relationship with small stems in Rodewald and Brittingham (2004) suggest that fall birds prefer a mid-successional shrubland that is not dominated by small stems and is not completely devoid of them either. Rodewald and Brittingham (2004) also pointed to fruit abundance of these early successional habitats as another important habitat selection factor for birds. Although fruit abundance was not included as a variable in the best model for total bird abundance, fruit species richness was included. These results add to the

increasing amount of literature that shows the importance of fruits to birds during the fall (Blake and Hoppes 1986, Parrish 1997, Suthers *et al.* 2000, Rodewald and Brittingham 2004).

Only one habitat model with a ΔAICc of less than 2.0 was generated for the American Robin. The strongest predictor was a positive relationship with total shrub cover suggesting that American Robins prefer well-developed, dense shrublands, although, I found few in early successional forests. This differs from their breeding habitat preference in the same region, as Klees (2008) found that American Robin abundance decreased with increasing shrub cover. American Robins also preferred habitats that had fewer shrub stems, as shown by the negative relationships with both stem classes 1 and 2, despite the positive relationship with shrub cover. These two results might suggest that habitats with few, large and sprawling shrubs are the preferred habitat. The best model also included a significant positive relationship with buckthorn fruit abundance. This agrees with my fecal analysis results that suggested that robins eat buckthorn at a disproportionate rate relative to the species' fruit abundance.

Gray Catbirds had two habitat models with a ΔAICc of less than 2.0 and both included fruiting shrub species richness as a positive predictor of abundance. This positive relationship with fruiting shrub species richness is interesting, as a similar variable, plant species richness, was positively correlated with Gray Catbird habitat use in western New York shrublands during the breeding season (Klees 2008). Although Cimprich and Moore (1995) suggested that Gray Catbirds increase their use of forest habitat during migration, my data did not support this pattern. One forest

patch did contain a few Gray Catbirds, but this site had a well-developed understory with mature honeysuckle shrubs. My results for Gray Catbird habitat use were similar to those for the American Robin because habitat preferences of both species apparently differed somewhat between the breeding season and fall.

The Song Sparrow was the only common species in my study that has declined significantly in New York State over the past 50 years (Sauer *et al.* 2008). The best habitat model included three habitat variables: stem class 1 abundance, and honeysuckle and gray dogwood fruit abundance. A negative relationship between Song Sparrow detections and stem class 1 might be related to the fact that the species typically occurred in fields with larger and older dogwood plants with more fruit. The remaining two variables showed that Song Sparrows occurred more in areas with higher levels of gray dogwood fruit and lower levels of honeysuckle fruit.

Fruit

The fruit removal experiment and fecal analysis were designed to answer two important questions: do birds consume fruit in shrublands and forests in the fall, and if so, which fruiting species do they prefer? Approximately 28% of the fecal samples did show evidence of frugivory and my data suggested that the birds were selective in their fruit consumption, mostly avoiding native dogwood and consuming more of the exotics bella honeysuckle and common buckthorn. I do not know to what extent fruit coloration, regurgitation, or digestion (Rosenberg and Cooper 1990) played a role in fruit detectability in the feces. Despite this question, I felt this was the best method to determine frugivory levels given the resources, time, and constraints available. My results also showed relative levels of frugivory among bird species consistent with

those in the literature (Parrish 1997). The three most frugivorus birds in my study were Gray Catbird, Cedar Waxwing, and American Robin; all showed evidence of frugivory in at least 50% of the samples. The remaining species, American Goldfinch, Black-capped Chickadee, Common Yellowthroat, Song Sparrow, and White-throated Sparrow, had evidence of frugivory in less than 20% of the fecal samples (Figure 2). My frugivory percentages are lower than data reported for the same species in Parrish (1997), who worked with fall migrants in Rhode Island; however, they agree on the relative ranking of birds in relation to frugivory.

The results of the fruit consumption experiment support those for the fecal analysis. The experiment suggested that fall birds eat fruit at stopover sites and, more interestingly, seem to consume the invasive bella honeysuckle while avoiding the native gray dogwood, which would explain the lack of dogwood in fecal samples. Lafleur *et al.* (2007) reported that in choice trials American Robins and European Starlings (*Sturnus vulgaris*) often preferred invasive fruits, though they speculated that the response is potentially species-specific for both the frugivore and fruit species. My data do not agree with Drummond (2005), who used a similar branch exclosure method and reported that fall frugivores did not differ in their consumption of the invasive tartarian honeysuckle (*Lonicera tartarica*) and native silky dogwood (*Cornus amomum*), two species closely related to those I used in my fruit removal experiment. While my data suggested a difference in consumption between native and exotic fruit species during the fall, a more comprehensive study using a wide range of fruit species is necessary before we can state that migrants preferentially consume invasive fruits.

Among studies looking at nutritional content of fruits, few have looked directly at the shrub species I encountered; however, some have reported on closely related species. Drummond (2005) reported that fruits of tartarian honeysuckle, a parent of the hybrid bella honeysuckle, had significantly less energy than silky dogwood. While other nutritional aspects were not listed in Drummond (2005), Whelan and Willson (1994) showed that roughleaf dogwood (*Cornus drummondii*) had a greater lipid content than the introduced amur honeysuckle (*Lonicera maackii*). Higher lipid content would translate into higher energy content, since lipids contain more energy than carbohydrates. If these nutritional trends hold true for the fruiting species found in this study, the preferential consumption of bella honeysuckle would require the migrants to consume more fruit to gain similar amounts of energy as from the natives.

Conservation and Management Implications

My results show that: 1) many bird species prefer shrublands to forests during the fall; 2) the presence of fruiting species may be an important factor in habitat selection for these birds; 3) many bird species consume fruits present in shrublands during the fall. Given the apparent importance of shrublands and the fruiting species they contain for fall migrants and residents, the recent decline in early successional habitats in the Northeast should be viewed with concern (Litvaitis 1993, Foster *et al.* 2002). Moreover, early successional areas such as shrublands are highly susceptible to invasive shrub species, such as bella honeysuckle and common buckthorn, as these species are often "r-strategists" (Rejmanek and Richardson 1996). My data showed that fall birds tend to prefer habitats with increased fruiting shrub species richness;

therefore, encroachment by exotic invasives could reduce the amount of available quality shrubland habitat by creating monocultures. However, fecal sample and fruit removal data suggest that migrants prefer the invasives bella honeysuckle and common buckthorn to the native dogwood. Also, some sites at INWR dominated by exotic shrubs supported many birds during the fall. While I do not suggest encouraging these exotics at places such as INWR, the cost of complete removal make it impractical. Some of the fields surveyed at INWR were very dense and completely overgrown with invasives. Complete restoration of these fields, including brush-hogging, plowing, planting, and long term management, would be very costly, especially given the resource constraints many managing agencies have. Understanding the costs involved and the fact that these fall birds appear to do well with invaded sites at INWR, a management plan whose goal is the complete removal of these exotic shrubs might not be the best use of resources. However, managers must balance the need for fall bird habitat with all other ecosystem needs and consider effects on the biological integrity, diversity, and environmental health before making this decision (USFWS 2009). Future studies should examine how well migrants perform (e.g. mass gained during stopover) by consuming invasive fruits to see if shrub habitats dominated by invasive, fruit-bearing species act as ecological traps (Schlaepfer *et al.* 2002). Also, more research looking at management of closely related natives of bella honeysuckle and common buckthorn should be performed to see if they provide the same habitat qualities as the invasives.

Low levels of small shrub stems and increased fruiting shrub species richness appear to provide the best habitat for fall migrants and residents at INWR. Thus,

employing management techniques encouraging increased fruiting shrub species richness and fewer stems will provide the best habitat for this suite of birds as a whole. Best habitat models differed among species, suggesting that no one management technique will provide the best habitat for all birds during the fall migration. Habitat management targeting individual species may be difficult for places such as INWR due to limited resources; therefore, using the "All-Bird" habitat model to direct habitat management might be a good trade-off between habitat quality and resource use. Finally, these models suggest that habitat use for some species during the fall is different from that during breeding season. This highlights the need for more research focusing on stopover habitat to allow for better management for songbirds during the fall, one of the Northeast priorities defined by Partners in Flight (Donovan *et al*. 2002).

Tables

Total Bird Abundance Habitat Models						
RANK	**AICc**	**ΔAICc**	**Wi**	**K**	**Variable**	**β**
1	70.48	0.00	0.43	3	Year	0.743
					Stem1	-0.597
					#Fruit Spp	0.984
2	70.92	0.44	0.42	4	Year	0.719
					Stem1	-0.733
					Area	-0.371
					#Fruit Spp	0.838
3	73.07	2.59	0.12	5	Year, [Stem1], [Area], #FruitSpp, Area*#FruitSpp	
4	76.37	5.89	0.02	6	Year, [Stem1], [Area], #FruitSpp, Area*#FruitSpp, Fruit Index	
5	80.46	9.97	0.00	7	Year, [Stem1], [Area], #FruitSpp, Area*#FruitSpp, Fruit Index, Olive Fruit Index	
6	86.16	15.68	0.00	8	Year, [Stem1], [Area], #FruitSpp, Area*#FruitSpp, Fruit Index, OliveFruit GrayDogFruit	

Table 1: Best habitat models for all bird species combined from shrubland data only. Models with ΔAICc < 2.0 contain beta values for each variable. Models with ΔAICc > 2.0 are condensed and do not contain beta values. Brackets signify negative relationships. Variable definitions are found in Appendix 2.

AMRO Habitat Model					
RANK	**AICc**	**ΔAICc**	**Wi**	**Variable**	**B**
1	133.61	0.00	0.32	Shrub Cover	2.93
				Stem1	-2.439
				Stem2	-1.985
				BuckFruit	1.239
2	136.31	2.69	0.26	ShrubCover, [Stem1], [Stem2], BuckFruit, #FruitSpp	
3	140.90	7.28	0.21	ShrubCover, [Stem1], [Stem2], BuckFruit, #FruitSpp, HoneyFruit	
4	150.24	16.63	0.13	ShrubCover, [Stem1], [Stem2], BuckFruit, #FruitSpp, HoneyFruit, [Area], [Area*ShrubCover]	
5	157.01	23.39	0.09	ShrubCover, [Stem1], [Stem2], BuckFruit, #FruitSpp, HoneyFruit, [Area], [Area*ShrubCover], FruitIndex	

Table 2: Best habitat models for American Robin from shrubland data only. Models with ΔAICc < 2.0 contain beta values for each variable. Models with ΔAICc > 2.0 are condensed and do not contain beta values. Brackets signify negative relationships. Variable definitions are found in Appendix 2.

GRCA Habitat Models					
Rank	**AICc**	**ΔAICc**	**Wi**	**Variable**	**β**
1	94.555	0.000	0.196	Year	1.118
				# Fruit Spp	1.167
2	95.073	0.518	0.191	# Fruit Spp	1.095
3	99.76	4.69	0.155	#FruitSpp,Year, [GrayDogFruit]	
4	99.63	4.56	0.156	#FruitSpp,Year, [GrayDogFruit], ShrubCover	
5	103.48	8.41	0.129	#FruitSpp,Year, [GrayDogFruit], ShrubCover, Stem1	
6	108.02	12.95	0.103	#FruitSpp,Year, [GrayDogFruit], ShrubCover, [Stem1], Stem2	
7	115.41	20.34	0.071	#FruitSpp,Year, [GrayDogFruit], ShrubCover, [Stem1], Stem2, [Area*#FruitSpp],[Area*ShrubCover]	

Table 3: Best habitat models for Gray Catbird from shrubland data only. Models with ΔAICc < 2.0 contain beta values for each variable. Models with ΔAICc > 2.0 are condensed and do not contain beta values. Brackets signify negative relationships. Variable definitions are found in Appendix 2.

SOSP Habitat Models					
Rank	**AICc**	**Delta AIC**	**Wi**	**Variable**	**β**
1	95.62	0.00	0.22	Year	0.693
				Stem1	-0.999
				RedPanFruit	0.524
				HoneyFruit	-0.322
2	95.73	0.11	0.22	RedPanFruit	0.375
3	95.88	0.26	0.22	Stem1	-0.699
				RedPanFruit	0.532
4	104.32	8.70	0.14	GrayDogFruit, [Stem1], Year, [HoneyFruit], #FruitSpp	
5	108.92	13.30	0.11	GrayDogFruit, [Stem1], Year, [HoneyFruit], FruitSpp, BuckFruit	
6	114.17	18.55	0.09	GrayDogFruit, [Stem1], Year, [HoneyFruit], #FruitSpp, BuckFruit, [Stem2]	

Table 4: Best habitat models for Song Sparrow from shrubland data only. Models with ΔAICc < 2.0 contain beta values for each variable. Models with ΔAICc > 2.0 are condensed and do not contain beta values. Brackets signify negative relationships. Variable definitions are found in Appendix 2.

Chi-Square Goodness of Freedom Results

	Observed N	Expected N	Residual
Honeysuckle	5	2.1	2.9
Dogwood	2	9.6	-7.6
Buckthorn	12	7.3	4.7
Total	19		

Table 5: Observed and expected cases of frugivory from fecal samples.

Figures:

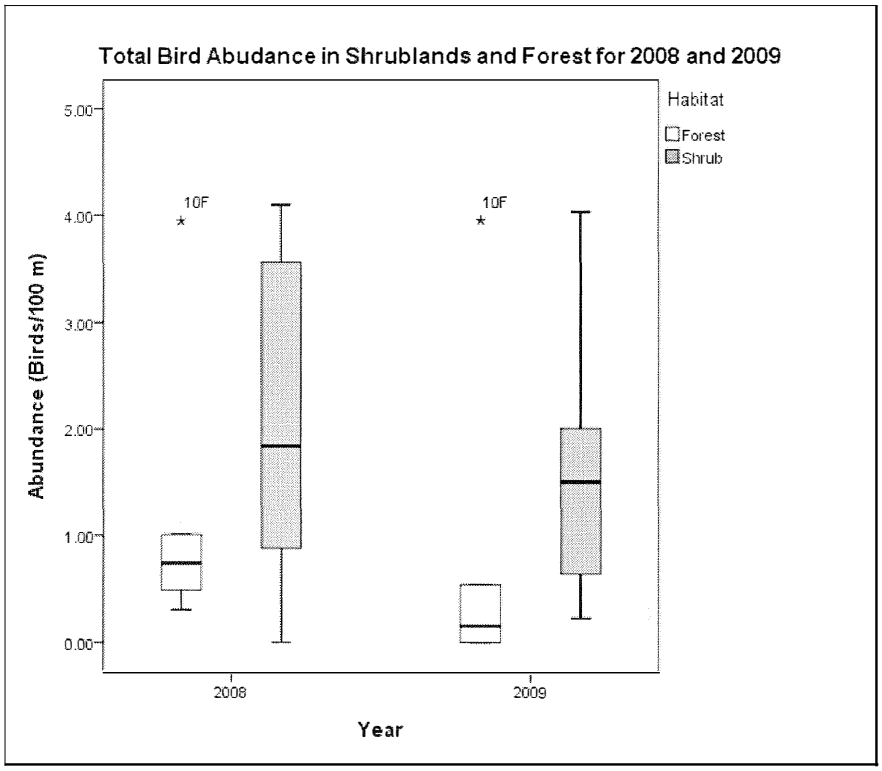

Figure 1: Boxplot of transect bird abundance for all forest and shrubland sites in 2008 and 2009. The solid line, box, and whiskers represent the median, interquartile ranges, and minimum/maximum values, respectively.

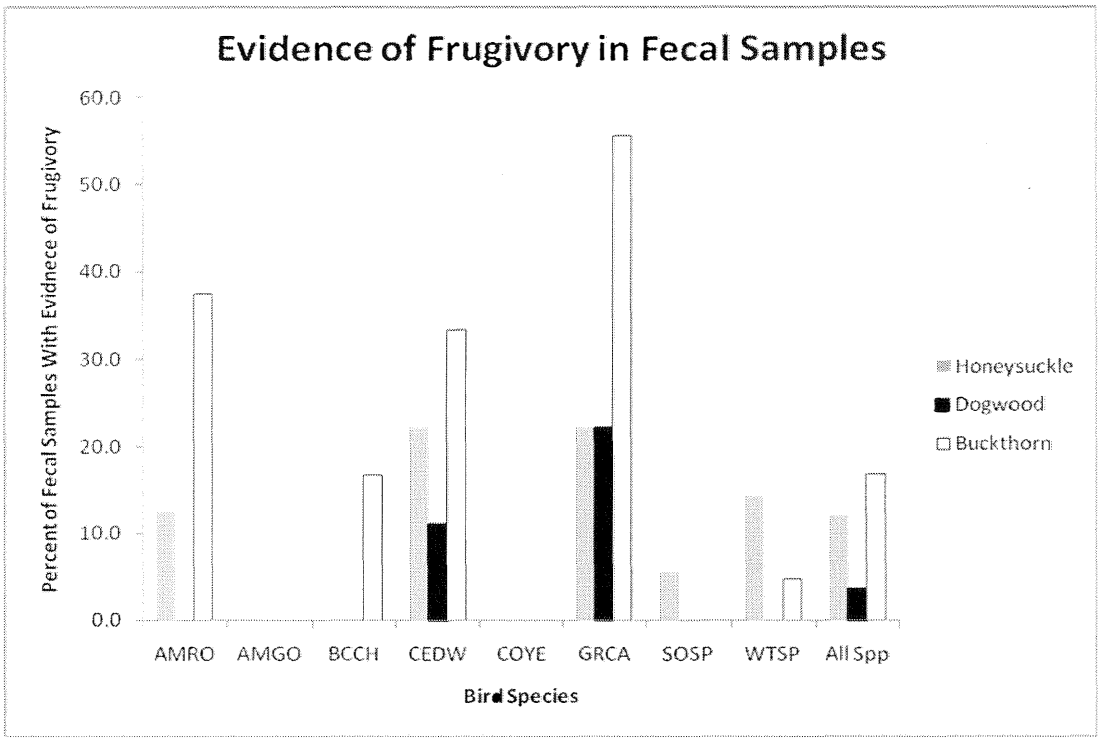

Figure 2: Percent of fecal samples showing evidence of honeysuckle, dogwood, and buckthorn fruit consumption for American Robin, American Goldfinch, Black-capped Chickadees, Cedar Waxwing, Common Yellowthroat, Gray Catbird, Song Sparrow, White-throated Sparrows and all species combined (data from fields 7S, 13S, and 13F). Note: Some samples contained material from > one fruit species, therefore maximum evidence of frugivory is greater than 100%.

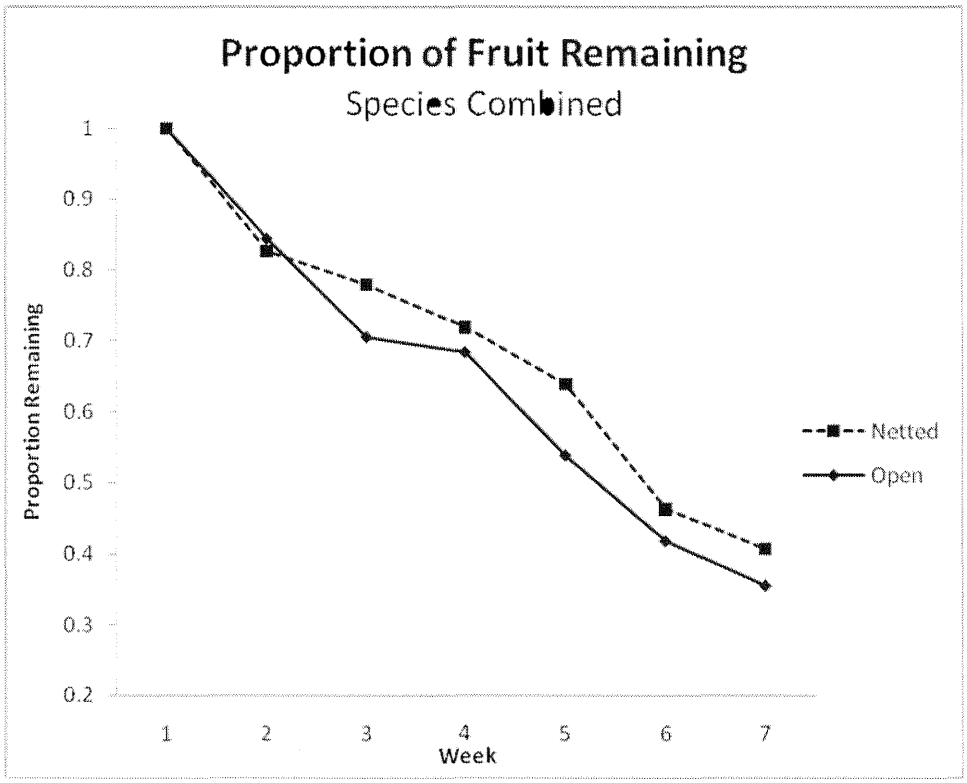

Figure 3: Average proportion of fruit remaining (untransformed data) for both netted and open branches during the seven week study with bella honeysuckle and gray dogwood combined.

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Appendices:

Year	Field	ShrubCov	Stem1	Stem2	Honey1	Honey2	FruitIndex	HoneyFruit	BuckFruit	GrayDogFruit	RedOsierFruit	FruitSppNum	Area
2008	2	61.3	210.3	15.0	7.2	0.0	29.5	0.3	1.6	26.1	0.0	6.0	1.57
2008	3	90.0	486.0	15.3	76.0	0.0	27.3	6.9	0.0	20.4	0.0	2.0	2.37
2008	5	76.3	443.5	10.5	0.3	2.0	0.5	0.0	0.0	0.0	0.3	1.0	1.02
2008	6	42.5	259.0	2.5	0.0	0.0	32.6	0.0	8.9	22.6	0.4	4.0	1.34
2008	8	94.3	38.0	29.0	34.3	28.5	78.9	75.5	0.0	0.5	0.0	3.0	8.32
2008	10	36.3	123.5	17.0	28.5	1.0	13.9	1.5	1.9	9.9	0.0	3.0	1.01
2008	11	57.5	285.8	26.0	139.8	3.0	9.0	8.8	0.0	0.0	0.0	2.0	3.19
2008	13	75.0	210.3	71.4	25.2	15.8	27.4	13.1	4.0	5.9	0.0	5.0	2.47
2008	14	35.0	120.5	12.0	11.5	3.0	6.9	1.9	0.0	5.0	0.0	2.0	1.9
2008	15	75.0	333.3	10.0	9.0	0.0	31.8	0.0	0.0	26.4	0.0	3.0	2.89
2008	17	23.5	91.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
2008	18	53.8	329.8	5.3	0.0	0.0	1.3	0.0	1.1	0.2	0.0	2.0	8.4
2009	2	47.5	181.8	8.8	5.8	0.0	20.5	2.0	3.6	12.5	2.4	5.0	1.57
2009	3	86.3	398.5	20.2	66.5	0.0	19.7	4.3	0.0	15.1	0.3	3.0	2.37
2009	5	41.3	254.5	1.8	0.0	0.0	12.6	0.0	0.0	4.6	3.6	3.0	1.02
2009	6	67.0	329.3	9.1	4.5	0.0	29.4	0.0	6.3	16.6	6.6	3.0	1.34
2009	8	95.0	32.0	31.5	26.5	30.0	72.5	71.6	0.0	0.6	0.0	2.0	8.32
2009	10	23.8	89.4	29.5	25.7	1.0	9.3	2.3	0.0	7.0	0.0	2.0	1.01
2009	11	38.0	378.3	8.8	228.8	4.0	9.2	8.5	0.0	0.3	0.0	3.0	3.19
2009	13	77.5	176.5	34.3	39.8	9.0	37.5	3.2	10.8	14.2	0.0	5.0	2.47
2009	14	26.8	159.0	6.3	27.3	0.0	6.7	1.1	0.0	4.8	0.0	3.0	1.9
2009	15	72.5	289.0	8.4	17.3	0.0	44.5	0.0	0.0	42.6	0.0	2.0	2.89
2009	17	28.8	104.8	3.0	0.0	0.0	0.3	0.0	0.0	0.0	0.2	2.0	5.5
2009	18	37.5	329.8	5.3	0.0	0.0	0.1	0.0	0.0	0.1	0.0	1.0	8.4

Appendix 1: Variables used in habitat modeling. Variable names are explained in Appendix 2.

Variable Name	Definition
Year	Year
ShrubCov	Total estimated shrub cover (%)
Stem1	Average class 1 stems (0-2.5 cm) per plot (Count)
Stem2	Average class 2 stems (2.5-8.0 cm) per plot (Count)
Honey1	Average class 1 honeysuckle stems (0-2.5 cm) per plot (Count)
Honey2	Average class 2 honeysuckle stems (2.5-8.0 cm) per plot (Count)
FruitIndex	Total fruit index (sum of individual fruit indicies)
HoneyFruit	Bella honeysuckle fruit index
BuckFruit	Common buckthorn fruit index
GrayDogFruit	Gray dogwood fruit index
RedOsierFruit	Red osier dogwood fruit index
OliveFruit	Russian olive fruit abundance
FruitSppNum	Fruiting shrub species richness
Area	Site area (ha)

Appendix 2: Definition of habitat variables.

A Comparison of Mist Net and Transect Counts in Early Successional Habitat During Fall Migration

Introduction

Various ecological, morphological, and behavioral characteristics of North American migrants make them inherently difficult to study, particularly during the fall migration. During this portion of their annual cycle, many migrants are non-territorial, do not sing, have dull coloration, and have short residence times at stopover locations. These characteristics may make some species difficult to detect and identify, rendering population and habitat studies problematic. One method often used to quantify migrant songbird abundances is mist netting (e.g. Morris *et al.*1996, Champlin *et al.*2009). Mist nets are useful because they allow the researcher to capture many birds that visual counting methods may overlook due to problems with detectability during migration. Also, observer-related biases that are often present in point counts or transects are reduced when using mist nets (Karr 1981). Mist nets, however, are time-consuming to set up and use, and require state and federal permits. Transects and point counts have also been used in many migration studies (e.g. Swanson *et al.* 2003, Buler *et al.* 2007, Smith and Hatch 2008, and Packett and Dunning 2009), and have their own set of limitations. Transects and point counts may allow researchers to efficiently sample many more sites per day and season than do mist nets. However, problems with detectability in habitats with reduced visibility, particularly when many species are cryptically colored and less vocal, may yield inaccurate abundance estimates (Buckland 2006). Also, count methods are

more susceptible to bias due to differences in the ability of observers to detect species (Buckland 2006).

Previous studies have shown that early successional habitats, such as shrublands and pole-stage forests, provide important stopover habitat for fall migrants and residents (Rodewald and Brittingham 2004, Smith and Hatch 2008, Packett and Dunning 2009). Detectability is often poor for birds in these habitats and research projects often have limited funding; therefore, researchers must design studies that accurately assess migrant abundance while using resources wisely. The objective of this study was to compare results from mist net and transect studies during the fall migration in early successional habitats in western New York State. Understanding how abundance estimates obtained with these techniques compare to one another will help researchers choose a method best suited to their objectives given available resources. Evaluation of these methods in early successional habitats in the Northeast is particularly important because recent studies have shown that these habitats are important for fall migrating and resident bird species (Rodewald and Brittingham 2004, Packett and Dunning 2009, Chapter 1), and future research will need counting techniques that are both efficient and accurate.

Methods

Site Description

I compared counts of migrants from mist nets and transects in one shrubland and an adjacent forest site in the fall of 2008 and 2009, along with an additional shrubland site in 2009. All three sites were located in Iroquois National Wildlife Refuge (INWR) in Alabama, New York (43°6'44.6", 78°24'12.9"). The shrubland

used in both years (Field 13S) was 2.5 ha and was a dense, diverse habitat patch with 75% shrub cover, containing gray dogwood (*Cornus racemosa*), bella honeysuckle (*Lonicera X bella*), common buckthorn (*Rhamnus cathartica*), and some small areas of goldenod (*Solidago* spp.) and asters (*Symphyotrichum* spp.). The forest sampled in both years (Field 13F) was a second growth forest 2.1 ha in size with 56.9% canopy cover, immediately adjacent to Field 13S. Dominant trees included American elm (*Ulmus americana*) and green ash (*Fraxinus pennsylvanicum*) while the understory was moderately open (40% cover) and contained buckthorn, bella honeysuckle, and riverbank grape (*Vitis riparia*). The shrubland added in the second season (Field 7S) was a field of 8.4 ha 10 km from fields 13S and 13F. Field 7S was dominated by well-developed bella honeysuckle to ~2.0 m high, although some gray dogwood and riverbank grape were present; total shrub cover was 94.3%

Bird Counts

Transects ran the entire length along the long axis of each site. I cut walking lanes 2.0-3.0 m wide in each field to reduce noise while walking transects. I walked each transect (~1.0 km/hr) twice per mist net morning (see below), once immediately after nets opened and once before nets were closed. All birds were identified to species if possible using both sight and sound cues. Grouped categories were used (i.e. "Warbler" or "Sparrow") if an individual could not be identified to species due to its secretive nature and basic plumage, or to thick vegetation.

I placed six standard sized nets (12m by 2.6m, four-shelved, 30 mm mesh) haphazardly within 20 m of the transect in each shrub and forest site. I opened nets for the first ~4.0 hrs after sunrise two to three times each week during the fall

migration (1 Sept to 15 Oct) each year. Nets were checked at 30-min intervals and were closed if weather conditions became potentially harmful for netted birds.

Statistical Analysis

I analyzed the relationship between counts from mist nets (birds/100 net hours) and transects (birds/100 m, averaged between the two counts) for all species combined, "warblers", and the three species for which I obtained adequate sample sizes: Gray Catbird (*Dumetella carolinensis*), American Robin (*Turdus migratorius*), and Song Sparrow (*Melospiza melodia*). First, I z-transformed the data for each year/field combination independently and then pooled years and fields (Wang and Finch 2002, Smith and Hatch 2008). Z-transforming the data allowed me to analyze counting estimates with different units by adjusting for the two different scales (Wang and Finch 2002). I assumed the data from the two shrublands were independent due to the distance between them. I analyzed the relationship between mist net and transect counts using non-parametric correlations. Finally, I analyzed the relationship between the mist net and transect counts for the three common species, Gray Catbird, American Robin, and Song Sparrow, in one correlation by averaging the species count for each field/year combination, as done in Smith and Hatch (2008).

I compared species richness between the two counting measures with a two-way ANOVA for field 13S. I used date as the experimental unit and method and year as the two factors. I used a Wilcoxon signed rank test to compare species richness between mist net and transect counts in field 7S since the data were not normally distributed and there was only one year of data.

Results

In 2008 mist netting detected 138 and 7 birds in fields 13S and 13F, respectively, while transects detected 46 and 7 birds in fields 13S and 13F, respectively. In 2009 mist netting detected 73, 114, and 7 birds for fields 7, 13S, and 13F, respectively, while transect counts detected 111, 38, and 3 birds in fields 7, 13S, and 13F, respectively. Mist netting detected more species than transect counts for all fields in all years (Table 6). Of the 30 species detected during the study, 11 (36.6%) were detected in both mist nets and transects, 18 (60.0%) were detected in mist nets only, and one (3.3%) species was detected in transects only (Appendix 7). There was no significant difference in species detected per day between years for field 13S ($F_{1, 36}$= 2.874, p= 0.099). Mist netting yielded significantly more species per day (5.2) than transects (3.1: $F_{1, 36}$ = 16.717, p= 0.000), in field 13S across both years. In 2009 the difference in species richness between the two methods was marginal in field 7S (Wilcoxon: Z= -1.841, p= 0.066) where mist nets and transects detected 3.7 and 2.3 species per day, respectively. .

For all species combined, there was no significant relationship between the number of individuals detected by mist nets and transects in field 13S (r= -0.139, p= 0.536), field 13F (r= 0.035, p= 0.880), field 7S (r= 0.324, p= 0.478), or for all fields combined (r=-0.026, p=0.858) (Figure 4). I could not analyze data for individual species in field 13F due to insufficient data. Gray Catbird abundance estimates derived from mist nets and transects also showed no significant relationship in field 7S (r= 0.600, p= 0.154); however, there was a significant positive relationship for catbirds in field 13S (r= 0.756, p= 0.000) and when data from shrublands 13S and 7S were combined (r= 0.663, p =0.000) (Figure 5). Results were similarly mixed for

American Robins. There was no relationship between counts from mist nets and transects for either field 13S ($r= 0.332$, $p= 0.131$) or field 7S ($r= 0.241$, $p= 0.603$), but when the data from the two fields were combined, the positive relationship was marginally significant ($r= 0.351$, $p= 0.062$) (Figure 6). Song Sparrow mist net and transect correlations mirrored those for the American Robin. There was no significant relationship for field 13S ($r= 0.277$, $p= 0.212$) or field 7S ($r= 0.600$, $p= 0.154$), but the relationship was marginally significant when the two sites were combined ($r= 0.349$, $p= 0.064$) (Figure 7). In general, very few warblers were detected in transect counts while more were caught in the mist nets (Appendix 3). Warbler counts from mist nets and transects showed no significant relationship in field 13S ($r= 0.112$, $p= 0.619$), the only field with sufficient data for analysis (Figure 8). When abundances of Gray Catbirds, American Robins, and Song Sparrows were combined in one analysis, there was a significant positive relationship between data from mist net and transect counts ($r= 0.779$, $p= 0.001$) (Figure 9).

Discussion

My data contain mixed results on the relationship between mist net and transect counts for fall songbirds in early successional habitats. There was no relationship between mist net and transect counts when combining data for all species, fields, and years. There also was no relationship between the two methods for warblers. For individual species, few showed a significant relationship for individual fields; however, there were more significant relationships, particularly for larger, noisy species, when data from the two shrublands were combined. Finally, mist nets showed a greater species richness than transects. These mixed results

illustrate some of the challenges of counting birds in early successional habitats during fall migration.

The three common species analyzed individually, Gray Catbird, American Robin, and Song Sparrow, are all relatively large and easy to identify relative to many other species encountered in this study, such as the Common Yellowthroat (*Geothlypis trichas*), Magnolia Warbler (*Dendroica magnolia*), and House Wren (*Troglodytes aedon*). The increased ability to detect individuals of some species probably helped to generate significant relationships between transect and mist net counts when combining multiple fields. This suggests that for larger, more vocal species, the two methods can potentially generate similar estimates of abundance in shrub habitat during the fall migration, at least across a series of sites.

Based on my results, the use of transects to determine relative levels of abundance of fall migrants across habitats, sites, or season is potentially useful given several important qualifiers. First, one must consider the species being studied and understand how their behavior, morphology, and ecology during migration might influence their detectability during transect counts or mist netting. Some species, such as the American Robin, are rather large and noisy even during the fall migration. However, many species are small, drably colored, and quiet during the fall, and not counted as easily on transects. Detection probabilities (Thomas *et al.* 2010) also would limit studies whose goal is to determine species richness in shrub habitats during the fall. Mist nets consistently yielded a greater number of species per day and per season, suggesting that transects are not adequate to determine richness in shrublands during the fall. Understanding the detectability of the study species is

paramount before deciding to use transects in early successional habitats during the fall migration.

Smith and Hatch (2008) showed that mist net and transect counts in early successional habitats in Pennsylvania yield generally similar levels of relative abundance during migration. While they performed their study during spring migration, some similarities between our two studies suggest that transect counts may be useful for determining abundance during migration. However, detecting individuals in the spring might be easier due to lower vegetation densities, the possibility of individuals singing for some species, and brighter prealternate plumages. Wang and Finch (2002) also found similar relationships between mist net and point count data collected during spring and fall migration in New Mexico, but also found that larger species were underrepresented in mist net captures while smaller rare species were less frequently detected by point counts. While it is unknown how my transect data would compare to point count data, the two counting methods are relatively similar in that they are a less intensive, more observational approaches than mist nets. The general agreement between Wang and Finch (2002), Smith and Hatch (2008), and some of my findings (e.g. the mist net and transect relationship for GRCA) suggest that transects and point counts are potentially useful for counting fall birds in early successional habitats under certain circumstances. However, some of my other findings, such as the weaker relationship between mist net and transect counts for AMRO, SOSP, and for all species combined, suggest that these two methods do not always yield the same results.

Recommendations

An increasing number of studies have shown that early successional habitats in the Northeast are important for fall birds (Rodewald and Brittingham 2004, Packatt and Dunning 2009, Chapter 1). However, the dense structure of these habitats and secretive nature of some fall migrants may make it difficult to adequately sample birds. Data from Wang and Finch (2002) for spring and fall migrants in riparian habitat in New Mexico and Smith and Hatch (2008) for spring migrants in shrubland and forested habitat in Pennsylvania suggest that estimates of abundance and species richness derived from point counts or transects may compare to those from mist nets. Results from my study agree with those but with some large qualifications. First, identifying habitats, target species, and their ecology during migration must be done to determine the applicability of transect counts. Based on my results, transects are not appropriate to use for small, secretive birds such as warblers or wrens; therefore, mist nets are a better choice to estimate their abundance. Second, since migration stopover is highly dynamic, due to the biology of migrants and weather patterns, repeat visits are required to get an adequate sampling of abundance. My correlations were not significant for some species using one year of data; however, when I combined years to create 22 sampling dates, the correlations became significant. Finally, it appears that transects are not an adequate counting method to determine bird species richness in shrublands during the fall; therefore, studies whose goal is to determine richness should use mist nets. Given these qualifications, transects are potentially useful for determining abundance of large, noisy species, for describing broad patters of habitat use, and for monitoring efforts to make habitat management decisions.

Understanding that any counting method will have limitations, a combined approach to counting birds during migration may help to alleviate any biases. Mist nets may be a better method at detecting quiet species; however, they can only sample the bird community at the ground level (Remsen and Good 1996). As shown here, transects counts detect fewer species in early successional habitats, but are not limited to the ground level. This type of combined method has been suggested before (e.g. Rappole *et al*. 1998, Wang and Finch 2002, Smith and Hatch 2008). A hybrid mist net and transect count approach would potentially minimize limitations found in individual methods, detection probability for transect counts and limited height detection for mist nets, and create an increased confidence when comparing relative bird abundances among sites or years.

Table:

	2008		2009		
Field	**13S**	**13F**	**13S**	**7S**	**13F**
Mist Net	21	3	21	12	7
Transect	11	1	9	6	1

Table 6: Species richness for mist net and transect counts for each field and season.

Figures:

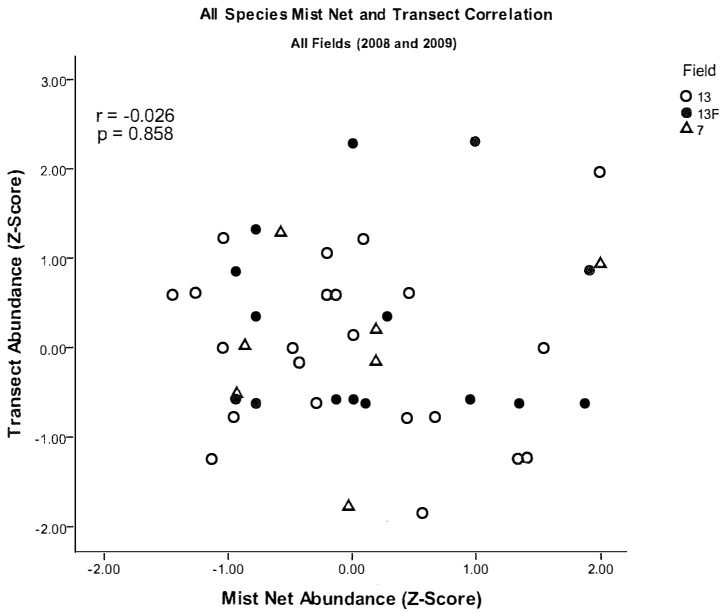

Figure 4: Scatterplot of mist net and transect abundances for total bird abundance from 2008 and 2009 in all three fields. One point represents total abundance for one sampling day in one field

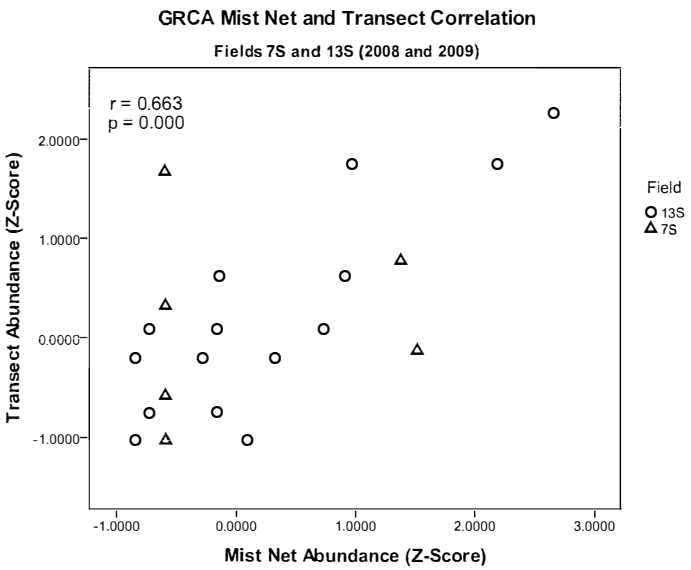

Figure 5: Scatterplot of mist net and transect abundances for Gray Catbirds from 2008 and 2009 in fields 13S and 7S. One point represents abundance for one sampling day in one field.

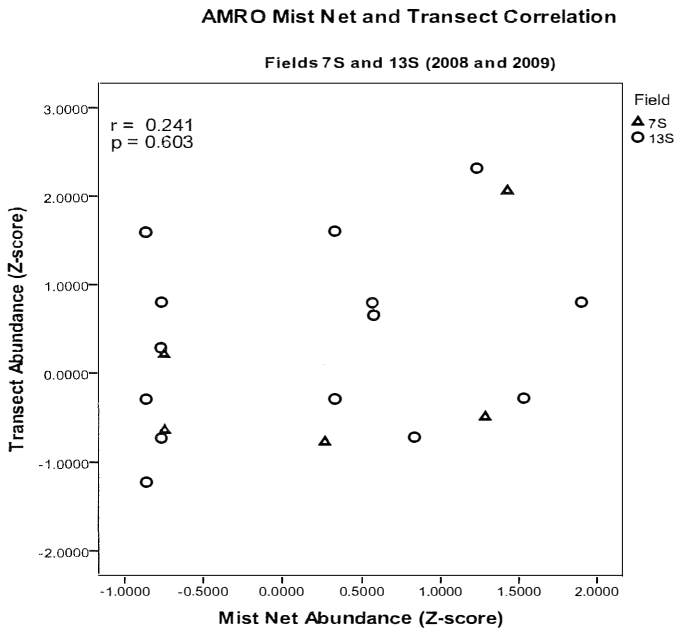

Figure 6: Scatterplot of mist net and transect abundances for American Robins from 2008 and 2009 in fields 13S and 7S. One point represents abundance for one sampling day in one field.

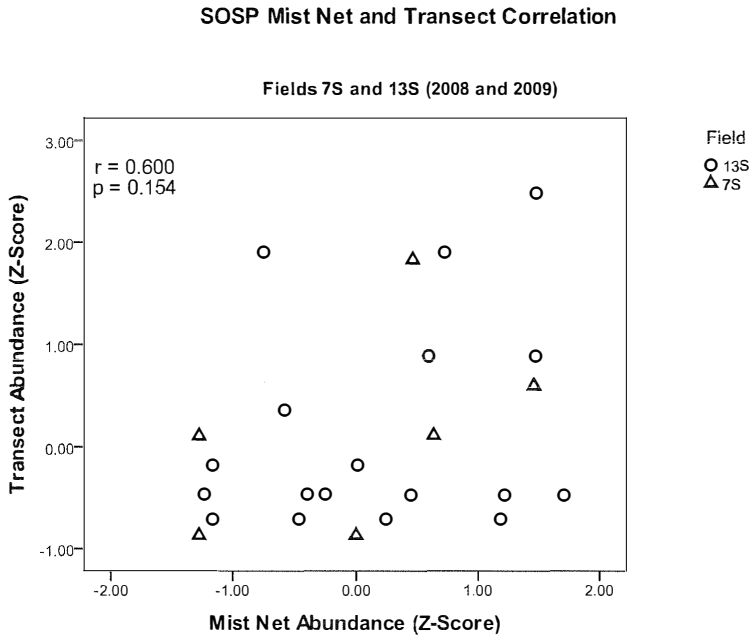

Figure 7: Scatterplot of mist net and transect abundances for Song Sparrows from 2008 and 2009 in fields 13S and 7S. One point represents abundance for one sampling day in one field.

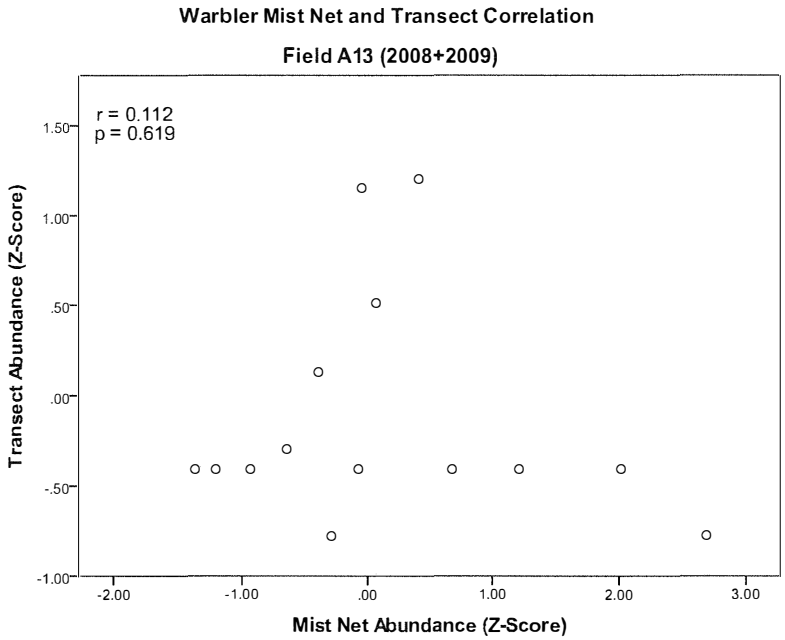

Figure 8: Scatterplot of mist net and transect abundances for Warblers from 2008 and 2009 in field 13S. One point represents abundance for one sampling day in one field.

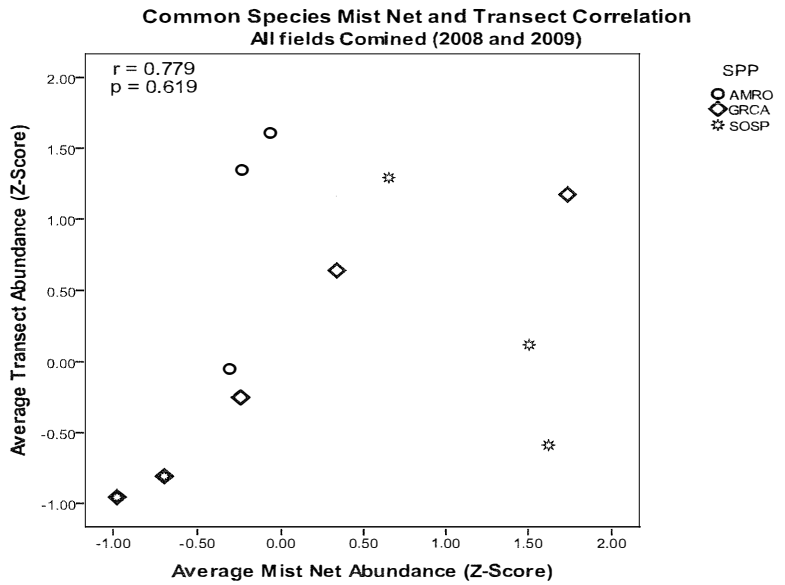

Figure 9: Scatterplot of mist net and transect abundances for American Robins, Gray Catbirds, and Song Sparrows combined from 2008 and 2009 in fields 13S, 13F, and 7S. One point represents the average abundance for a species in one field for one year.

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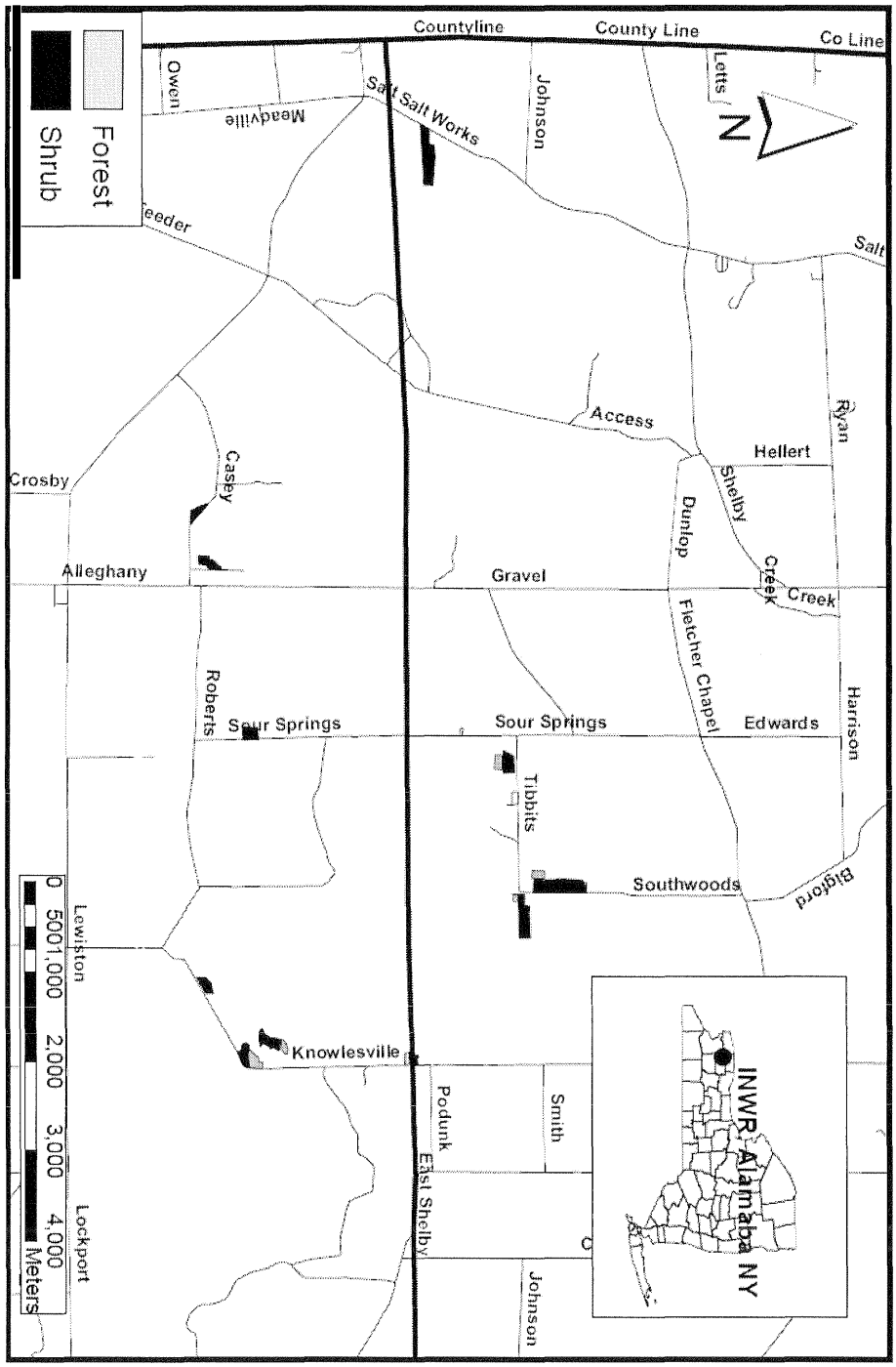
Appendces:

Spp Code	Common Name	Scientific Name	Method Detected
BLPW	Blackpoll Warbler	*Dendroica striata*	N
BTBW	Black-throated Blue Warbler	*Dendroica caerulescens*	N
COYE	Common Yellowthroat	*Geothlypis trichas*	B
MAWA	Magnolia Warbler	*Dendroica magnolia*	B
OVEN	Ovenbird	*Seiurus aurocapillus*	N
WIWA	Wilson's Warbler	*Wilsonia pusilla*	N
YRWA	Yellow Rumped Warbler	*Dendroica coronata*	N
GCKI	Gold-crowned Kinglet	*Regulus satrapa*	N
RCKI	Ruby-Crowned Kinglet	*Regulus calendula*	N
HOWR	House Wren	*Troglodytes aedon*	N
BCCH	Black-capped Chickadee	*Poecile atricapillus*	B
BRCR	Brown Creeper	*Certhia americana*	N
DEJU	Dark-eyed Junco	*Junco hyemalis*	N
LEFL	Least Flycatcher	*Empidonax minimus*	N
REVI	Red-eyed Vireo	*Vireo olivaceus*	N
AMGO	American Goldfinch	*Carduelis tristis*	B
PUFI	Purple Finch	*Carpodacus purpureus*	N
BLJA	Blue Jay	*Cyanocitta cristata*	T
CEDW	Cedar Waxwing	*Bombycilla cedrorum*	B
DOWO	Downy Woodpecker	*Picoides pubescens*	B
RBGB	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	N
AMRO	American Robin	*Turdux migratorius*	B
SWTH	Swainson's Thrush	*Catharus ustulatus*	N
VEER	Veery	*Catharus fuscescens*	N
WOTH	Wood Thrush	*Hylocichla mustelina*	N
GRCA	Gray Catbird	*Dumetella carolinensis*	B
CHSP	Chipping Sparrow	*Spizella passerina*	N
SOSP	Song Sparrow	*Melospiza melodia*	B
WCSP	White-crowned Sparrow	*Zonotrichia leucophrys*	B
WTSP	White-throated Sparrow	*Zonotrichia albicollis*	B

Appendix 3: List of species codes, common names, scientific names, and method detected (B=Both, N=Net only, T=Transect only) for all species encountered.



Appendix 4: Locations of sites used at Iroquois National Wildlife Refuge, Alabama NY.